

Come and Feel the Noise - A Review of Recreational Noise Associated with Two Open Air Concert Sites

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Abstract

Open air concert events can be held in specialist stadiums, arenas or open sites. These events are recreational activities which give enjoyment and pleasure to the people attending but can potentially cause disturbance and annoyance to bystanders in the surrounding environment. This disturbance can include interference with speech communication, interference with concentration, and general annoyance.

This article looks at the noise and the related effects from open air concert events using two well known sites in New Zealand namely Wellington's Westpac Stadium and Mystery Creek, Hamilton. These two sites have been used to provide examples of sound level measurements from open air concert events carried out on site.

The article endeavours to bring together a suite of fundamental physical and managerial methods for the effective control of environmental sound during open air concert events under the title of noise management methods.

Introduction

Electronically amplified open air concerts have been held for many years with well known bands such as The Beatles playing as early as the mid 1960s to what was then a record attendance of around 55,000 people at Shea Stadium, New York.

Open air concerts may be held in established locations such as stadiums or temporarily established locations in both rural and urban areas in residential or commercial settings. Most concert venues have some type of noise sensitive location within a few kilometres of the venue. In some cases dwellings have been established around existing open air concert sites causing potential reverse sensitivity noise issues [reverse sensitivity being the potential effect that development may have on activities already occurring in an area]. In New Zealand a large number of open air concerts and festivals are held in areas nearby to residential or rural residential sites.

There are various examples in New Zealand of locations used such as stadiums or open spaces i.e. parks and reserves. Events can range from a performance lasting a few hours, such as events held inside Wellington's Westpac Stadium, through to music festivals which may last for several days, such as the annual Parachute Music Festival at Mystery Creek, Hamilton.

For the purpose of this article an 'open air concert' is a concert taking

place outside as opposed to inside a concert hall or building structure which is fully enclosed. In the case of the two examples presented here the Westpac Stadium is a large semi-enclosed structure but has no complete roof structure. The outdoor stages at the Parachute Music Festival are large temporary structures located in an open air environment. The stadium site has been selected as an example as it represents a busy urban setting while Mystery Creek and its surrounds represent a rural setting.

Although the Westpac Stadium is located within a city and Mystery Creek in a rural area there are key similarities between the two sites. The Westpac Stadium and Mystery Creek sites both have audience attendance in the tens of thousands when hosting major outdoor concerts and both venues have noise sensitive sites within close proximity. One key difference with the two sites is the stadium is a semi-enclosed structure while Parachute at Mystery Creek is an entirely open site in terms of outdoor performance areas.

In the examples concert noise may include small concerts taking place on a single stage at the Parachute Music Festival through to much larger amplified sounds such as a heavy rock band performances like AC/DC at the Westpac Stadium.

Westpac Stadium, Wellington

The Westpac Stadium is located in Wellington. The stadium is used for major concert events ranging from David Bowie through to AC/DC. Between 2004 and the end of January 2010 the stadium hosted several major open air concert events, with one or more concerts per year on average. These nine events held on site since 2004 include David Bowie [14 February 2004], Neil Diamond [5 March 2005], Rolling Stones [April 2006], Elton John [6 December 2006], The Police [January 2008], Rock2Wgtn [22 & 23 March 2008] and AC/DC [28 & 30 January 2010]. Additional events which included amplified entertainment over this period were the Crusty Demons and WWE Wrestling. The stadium is also home to Wellington Rugby [Lions and Hurricanes] and Football [Phoenix].

The stadium site is approx 50,000 m² in size being built on reclaimed railway land approximately 1 km from the CBD and Wellington's major bus and rail hubs. The stadium was opened in early 2000 replacing Athletic Park which was previously used for major sporting events such as the first Rugby World Cup. The stadium has a general fixed seating capacity for 36,000 people.

Although the site is located on the outskirts of the CBD there are a number of noise sensitive sites such as residential dwellings nearby in the suburb of Thorndon and surrounding hill areas. Additional noise sensitive sites exist such as the Wellington Free Ambulance Head Quarters which hosts a call centre not

far from the stadium. Past background sound level measurements show the area has a medium to high background sound level from rail, road-traffic and port related noise sources. This level generally reduces at night.

The stadium's form plays an important role in the reduction of potential off-site noise effects as it provides a continuous structure which surrounds all sound sources such as people and temporary stages used for concerts. The stadium is surrounded by a concourse which provides for an inner and outer leaf to the structure with a large space between. This high 'double leaf' façade acts as an effective barrier helping reduce sound propagation travelling off-site.

Sound sources such as amplified music and people can be audible off-site when a concert event is occurring inside the stadium. These sounds escape from the stadium primarily because there is no full roof over the stadium. The open air portion of the stadium represents a large part of the overall surface area of the structure. Some sound will also escape through the building structure itself.

Figure 1 [Page 5] is a photo of the Westpac Stadium and its surrounding area as viewed from the air. Figure 2 [Page 5] shows the stadium as viewed

from pitch level, showing how the stadium is an open air environment.



Figure 1: Aerial view of Westpac Stadium.

Reference: www.365stats.com



Figure 2: Internal view of Westpac Stadium.

Reference: www.westpactstadium.co.nz

Parachute Music Festival, Mystery Creek, Hamilton

The Parachute Music Festival is a major annual music event for both Hamilton and New Zealand. The festival runs for three nights and four days and is well known as a Christian music

festival which hosts dozens of bands and musicians. There are several stages with amplified and acoustic music performances and a wide variety of other activities including fun rides and outdoor activities. The festival attracts between 20,000 and 30,000 people over the four days. Although the event is focused on celebrating Christian music there are a number of secondary activities during the festival which also produce modest sound emissions such as fun rides, traffic and people.

The Mystery Creek site is used for various events including the Parachute Music Festival. The site is based on the outskirts of Hamilton City in a rural setting. The site has a number of large building structures including the Central Building Pavilion. The remainder of the site is generally open space. Parachute Music has used the Mystery Creek site for the Parachute Music Festival since 2004. Generally

there are several stages on the site during the festival. The Main Stage is used for headliners, while smaller stages are used for other acts including local musicians. Although the set up changes each year, the Main Stage remains in the same place on site, with the remaining performance areas and stages being

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Figure 3: Aerial view of the Parachute Music Festival.

Reference: www.mysterycreek.co.nz

either outside or enclosed within the various building structures. In a typical year there would be as many as seven stages with three of these being located indoors. Measurements illustrate that it is the Main Stage which is the predominate sound source on site. Even when several other stages are operating simultaneously at the same time as the Main Stage, this stage still dominates off-site. This is due to the Main Stage having the “largest” sound system output.

Although the Mystery Creek site is itself a large generally flat rural site, the site does have limited shielding from

terrain between the site and Mystery Creek Road, which runs adjacent to the southern boundary of the site. There are a number of rural-residential sites within a few kilometres of the site in all directions. Hamilton’s International Airport is within a kilometre of the site as is the Mystery Creek Golf Course and Conference Centre. Measurements show the area has a low to moderate background sound level from sources such as aircraft over flights; road-traffic noise and general rural activity. The airport is often used for training which includes night flights and circuit training for pilots.

Figure 3 [Page 6] is a photo of the Mystery Creek site and the surrounding area as viewed from the air during the Parachute Music Festival.

Stakeholders Expectations

It is a major challenge for all parties involved in open air concerts to ensure the best outcomes are achieved for all stakeholders, including those off-site.

Concerts at both the Parachute Music Festival and Westpac Stadium are required to comply with set noise limits in the surrounding environment. The two venues assess compliance with set noise limits by carrying out acoustic

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monitoring during concerts to assess off-site sound levels at pre-determined locations.

Regardless of compliance with permitted levels, the expectations of the crowd may be totally different to neighbours. The crowd may be expecting very loud and intense levels of sound from a rock concert while the expectations of surrounding neighbours may be for no audible sound.

Regardless of whether events comply with permitted levels, sound can still be perceived as a major environmental problem for some neighbours. In certain cases neighbours may still contact the Council if sound is audible. There can be a significant gap between public expectations and permitted levels even when noise monitoring and mitigation is in place. This can relate to misunderstandings of how audible sound will be subjectively received even when at or below the permitted noise limits. Communication with the surrounding community is therefore an important part of the process. The fact that something is audible yet still fully complies with set noise limits is an important concept that is frequently misunderstood in environmental acoustics.

Another key stakeholder is the performance artist themselves. In some cases the artist may wish to control the level of sound or at least have a major input to the levels as it may be part of the performance or artists expectations. Examples include rock bands or heavy metal bands requiring high levels of sound to be produced as this is fundamental to their performance philosophy. This can provide conflict for event organisers, managers and the band themselves.



Figure 4: Common noise sources found at the Parachute Music Festival. Ref: Malcolm Hunt Associates ©

Legal Framework

Noise sensitive sites may include not only residential sites but also number of other sites which operate during both day and night such as care facilities [i.e. hospitals, rest homes] animal facilities [i.e. vet clinics, zoo parks], educational facilities [i.e. early childcare etc], call centres, and visitor accommodation to name but a few.

The level of sound received off-site is directly related to the onsite sound levels being produced. In New Zealand, under the Resource Management Act 1991 [RMA], territorial authorities [District or Regional Councils] have the primary responsibility for managing the effects of land uses, including noise. The concert operator will have to ensure they comply with any applicable noise regulations whether District Plan noise rules or conditions set down in a Resource Consent.

In New Zealand the persons/ management running a concert event bear the full costs associated with noise assessment and monitoring, management and supervision. In terms of noise management a key noise prevention concept applies that is action

should be taken where possible to reduce noise at the source.

In terms of general environmental noise, specific limits are usually set by rules in the district plan, for the protection of health and amenity. The noise from amplified sounds at an open air concert might not be able to comply with the permitted day or night noise limits set in a district plan, even with the best management methods in place. It may be unrealistic

in all cases to expect the levels a rock concert to be within those set down in the District Plan for everyday activities without having an effect on the overall 'experience' of the event.

In the case that permitted district plan rules cannot be met, increased levels might be reasonable for a short-term event, but Resource Consent usually needs to be applied for through Council. An Assessment of Environmental Noise Effects is usually submitted as part of a consent application, which should assess the expected noise effects and detail required noise controls. Controls usually entail both physical precautions such as the orientation of loudspeakers, and management based methods such as the supervision of people and music levels. If Resource Consent is granted it would normally be conditional on specific noise limits and management methods.

Some district plans recognise concerts and other cultural or recreational events as special 'temporary events' which may occur in the district as of right. In these cases Councils may allow for such events to occur by setting planning rules and management methods which include noise. District Plans may also allow

concerts as Controlled or Restricted Discretionary Activities, with specific consideration of matters such as hours of operation, duration and event frequency

Whether an activity is authorised by a District Plan or a Resource Consent, the provisions of Sections 16 and 17 of the Resource Management Act apply. Section 17 of the Act places an obligation on everyone to avoid, remedy or mitigate any adverse effect on the environment arising from an activity carried out by or on behalf of that person.

Section 16 of the Act places an obligation on every occupier of land to adopt the best practicable option to ensure that the emission of noise from that land does not exceed a 'reasonable level'.

What constitutes a 'reasonable level' of noise is not set out in the Act. Where specific noise limits exist in a district plan for temporary events, those would indicate what is reasonable - as opposed to the general noise limits in the plan. In the cases of Resource Consent, the limits set within noise conditions should constitute a 'reasonable level' of noise emission.

The fundamental principle behind any noise criteria is the concept that the best practicable option should be used to mitigate potential noise effects. The duty to adopt the best practicable option is in addition to the duty to comply with authority noise controls, and not in substitution. Therefore compliance with set limits may not always mean compliance with s16.

Noise Conditions

The Westpac Stadium has its own rules set out in the Wellington City District Plan under Chapter 13C. TE ARA HAUKAWAKAWA PRECINCT 'Stadium Site'. The Plan states there shall be no more than six special events in each calendar year and that each event shall not exceed 11 hours in any 24 hour period. The Wellington City District Plan includes more lenient noise limits for these special events compared to general activity on the site. Specifically, the plan rules state that noise generating equipment used as part of a special event shall be designed,

tested and operated to not exceed 55 dB LA10 [7am to 12 noon], 75 dB LA10 [12 noon to 11pm], 45 dB LA10 and 75 dB LAmx [11pm to 7am].

The Wellington City District Plan also states that the measurement period shall not exceed 5 minutes when assessed at two locations being 1) within 1 m of the physical road side edge at the south corner of Davis and Hobson Streets; and 2) at a site on the east side of, and between 20m and 30m from the north end of Frandi Street. The rule also requires that noise levels shall be monitored for the duration of the event in accordance with NZS 6801:1991 and the results shall be made available to the Council.

In regards to monitoring and calibration of the sound system the Wellington City District Plan also sets rules for sound testing and tuning of equipment and rehearsals for special events. These are must be after 9.00am on the day of the event, for no more than three hours, and finishing at least two hours before the event.

The Parachute Music Festival has a Resource Consent which governs environmental noise emissions, monitoring and assessment. There is a 55 dB LA10 [5min] noise control boundary which has been based on predictions of all stages operating simultaneously. There are five assessment locations around the circumference of the Mystery Creek noise control boundary where noise must be measured during the event. Monitoring is carried out at all five locations during the four day event. The consent conditions take account of weather conditions and allow an additional 4 dB under weather conditions that would give rise to enhanced propagation.

At Westpac Stadium and the Parachute Music Festival, event organisers/operators calibrate the sound system[s] before events and assess real-time noise emissions during events. Both events must report the findings and measurements to Council for assessment.

For both the Westpac Stadium and Parachute Music Festival the Council and event organisers have protocols in place that remove the need for after

hour's council noise control services. During the event, any complaints are investigated by the acoustic consultants appointed by the organisers rather than the afterhour's Council noise control service. The consultant can advise of objective levels and compare these to the permitted levels, triggering immediate action is required. In other applications, the council after hour's noise service generally do not carry out any sound level measurements and are only required to make a subjective assessment of 'excessive noise'. Time is also critical and the acoustic consultant is on-site and immediately available during the event.

The noise limits in both these cases include crowd noise as well as music. However, the Environment Court Decision No. A130/97 for Eden Park in Auckland specifically excluded crowd noise from the limits in that case. The Court considered that restrictions on the number of [night] games each year and the hours of operation will adequately to mitigate potential crowd noise.

Sound Sources

Open air concerts include amplified voices and instruments, and audience applause, singing and shouting. There may also be numerous other sound sources such as mechanical plant and people and vehicle movements to and from the site.

Primary sound sources maybe described as [but not necessarily limited to] the following:

- Playing of music through sound system[s] as live bands or background music;
- People talking, crowd yelling, crowd clapping and socialising, people entering and exiting the site;
- Organisers and trades people setting up and dismantling the site [vehicle reversing alarms, crew noise, waste management activities [rubbish/recycling], mobile plant i.e. forklift and pallet jacks]
- Vehicle movements on site and surrounding streets from people travelling to and from the site;
- Sound from mechanical services and plant associated with venues,

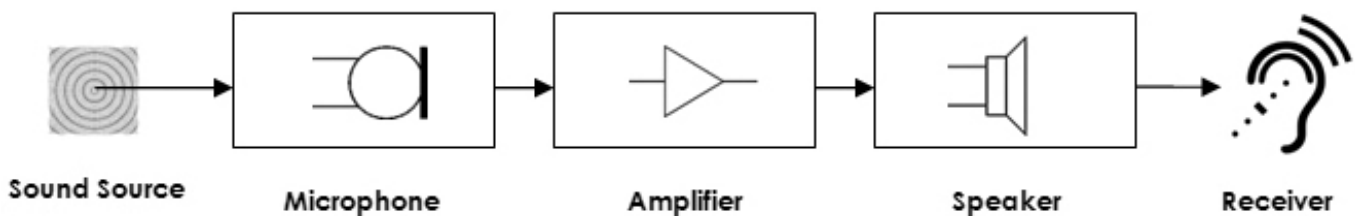


Figure 5: Schematic of basic sound system. Ref: Malcolm Hunt Associates ©

including fixed and mobile plant such as power generators.

- Sound from fireworks, pyrotechnics, helicopter over-flights, carnival rides.

Figure 4 [Page 8] illustrates a photo of common sound sources associated with open air concert events held on the Mystery Creek site during the Parachute Music Festival. The noise sources in the photo include amplified sounds, people, generator noise, compressor noise and vehicle noise.

Sound System Design

The main sound source associated with open air concerts is the sound system. Sound system requirements for open air concerts can be demanding and depend on various factors including the overall characteristics of sound which is required to be produced for the audience, including adequate sound levels. Although very high sound levels can appear impressive, loudness can interfere with the desired sound characteristics. Furthermore, the level at which concert sound is acceptable will depend not only on the opinions of the performer and the Audio Engineer but also on environmental noise controls and health and safety limits.

The Audio Engineer will calibrate the sound system before use to ensure they have the desired response. Because the human ear is dynamic in its own response, calibration for the derived sound characteristics can be a challenge. There are various electronics tools for calibrating a sound system used by Audio Engineers which allow calibration of the system to sound as close as possible to the original source material. However analysis by the human ear is key for the final calibration.

The sound system takes sound waves and converts these into an electric current, manipulating this electric current as desired, then converting this

back into sound waves. A simple way of visualising this is by dividing it into three key areas being [A] source [B] processor and [C] output.

A large multi kilowatt sound system used for outdoor concerts can be very complex however the basic principles still apply. The first stage is the 'source' where the sound is produced i.e. human voice, musical instruments etc. The sound waves produced by the various sources are detected by a microphone which converts them to electrical signal. The second section is 'processing', where the electrical signal from the microphone is manipulated and amplified. The final section is the 'output' where the amplified electrical signal is converted back into sound waves by the use of loudspeakers.

Figure 5 [Page 9] is a schematic of the above system description.

Prediction Methods and Models

The environmental impacts and related noise effects can be determined before an event occurs by use of prediction models. These provide one method to assess sound and demonstrate expected sound pressure levels in the receiving environment. Predicted levels also help inform Resource Consent applications; an example being the assessment carried out for the Parachute Music Festival and related noise control boundary.

An acoustics model generally presents predicted results as contours of equal sound levels. The model requires [at a minimum] several key variables:

- Topography of the subject site and surrounding area,
- Sound power level and frequency content of different sound sources,
- Location of the sound sources,
- Location of dwellings and other

noise sensitive sites,

- Operational scenarios of the event.

The acoustics prediction model is usually based on a series of accepted algorithms that take account of:

- Multiple or single noise sources,
- Sound power levels,
- Source, receiver and terrain heights,
- Directivity and radiation efficiency of large surface area emission sources,
- Octave band air absorption losses,
- Meteorological effects [wind, temperature, inversion layers etc].

The following are commonly used algorithms for sound propagation outdoors:

ISO 9613-1:1996 and ISO 9613-2:1996 Acoustics - Attenuation of sound during propagation outdoors - This standard provides complex guidance on calculating the propagation of sound outdoors. It shows how to calculate the effects of many factors including barriers, ground absorption and air attenuation. ISO 9613 is implemented by most computer modelling packages such as SoundPlan. The accuracy of the ISO model is quoted at between 1 to 3 dB at distance up to 1000 m from the sound source.

CONCAWE - The CONCAWE method is a semi-empirical model. It includes correction factors based on experimental data for geometrical spreading, atmospheric absorption, ground attenuation, and metrological conditions. A statistical analysis carried out in the CONCAWE Report found that the method could calculate the sound pressure level with 95% confidence to within ± 7 dB for most situations.

SoundPLAN is one of several computer



Figure 6: Sample of noise model output. Ref: Malcolm Hunt Associates ©

software packages, which implement a choice of numerous propagation algorithms including ISO 9613 and CONCAWE. As with most modern sound prediction programs the output in terms of A-weighted decibels [dB] is usually presented in 2 or 3 dimensional graphics. SoundPLAN also allows analysis across the frequency spectrum such as contours at low frequencies i.e. 63 Hz, which can be important for low frequency bass sounds.

Figure 6 [Page 10] is the output from a prediction noise model with the contour overlaid on a geo-referenced aerial photos. The model was prepared based on several sound stages [and secondary sources] with multiple sound power levels and frequency spectra, with surrounding terrain for the Parachute Music Festival.

Sound Pressure Levels

The sound pressure levels associated with concerts depend on the type of music i.e. a single unamplified vocalist would be a different type and level of sound compared to a large amplified rock band. In terms of larger amplified open air concerts examples from the Parachute Music Festival and Westpac Stadium are given in this article.

Figure 7 [Page 10] shows the sound pressure level range within the stadium

at six sample events held at the Westpac Stadium: David Bowie, Elton John, Neil Diamond, Rock to Wellington, The Police and Crusty Demons.

The sound pressure level shown is the log average sound pressure level taken from each concert event over a performance period of 2 hrs and 45 minutes. Table 1 [Page 12] illustrates the minimum, maximum, and average from these six events in terms of time-average

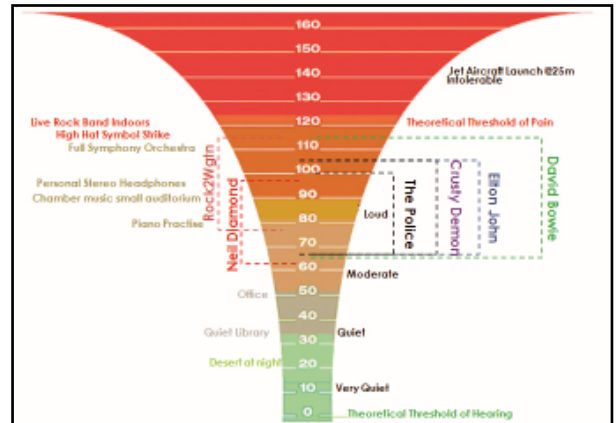


Figure 7: Schematic of the time-average level dB LAeq[2.45hrs] for six concert events at the Westpac Stadium, Wellington. Ref: Malcolm Hunt Associates ©



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	Minimum Sound Pressure Level dB LAeq	Maximum Sound Pressure Level dB LAeq	Average [log] Sound Pressure Level dB LAeq	Sound Exposure Level [1 second] dB LAeq
David Bowie	64	112	93	133
Elton John	67	103	91	131
Neil Diamond	61	97	86	126
Rock to Wellington	78	112	99	139
The Police	65	100	94	134
Crusty Demons	68	105	92	132

Table 1: Measured minimum, maximum and average measured equivalent continuous sound pressure level [dB LAeq] and [Lae] for six concert events at the Westpac Stadium for 2.45hrs, Wellington. Ref: Malcolm Hunt Associates ©

level [LAeq [2.45hrs)]. The average is over a performance period of 2 hrs and 45 minutes.

Figure 8 [Page 12] is a time varying sound level measured within the Westpac Stadium during the Elton John concert. In this figure the area marked 'A' relates to background sound, the area marked 'B' relates to secondary sound sources such as crowd noise and

background music, and the area marked 'C' relates to performance of the bands while on stage.

Figure 9 [Page 13] provides a sample measurement from within the Parachute Music Venue of the time varying and third octave frequency analysis approximately 30m from the Main Stage at the Parachute Music Festival during a performance of a rock band. The third

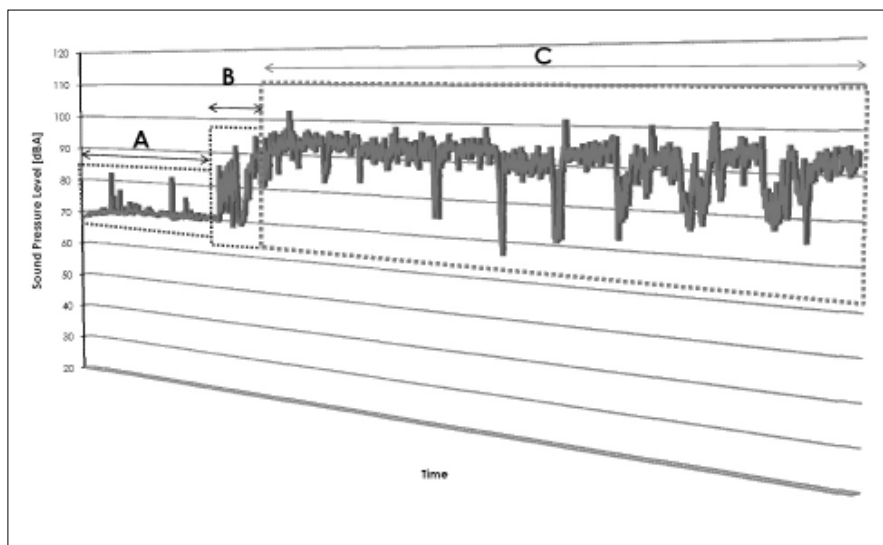


Figure 8: Sample of measured time-average sound level [dB LAeq[2.45hrs] for Elton John concert event held at the Westpac Stadium, Wellington. Ref: Malcolm Hunt Associates ©

octave sample relates to the performance of the band; note the high levels of low and mid-frequency sounds.

Figure 10 [Page 14] shows a sample of concurrent time varying sound levels at a distance of approx 30m from the sound source and at a distance of approximately 750m from the sound source at a receiving rural residential location.

The sample was carried out over four days from the Parachute Music Festival with various stages operating at different times. The graph shows the general pattern that when there is an increase in sound levels on site at the festival from amplified sounds there is generally a corresponding increase at the rural residential location. At other times when there is negligible sound from the festival site the background

sound levels control the sound at the rural residential location i.e. people, cars and general rural activities.

Both weather and extraneous noise may increase sound levels at receiving sites and it is important to assess only the sound source under investigation or be able to ascertain the difference between the specific sound, total sound, and residual sound. This is critical as a sound level meter cannot differentiate between sound sources.

Figure 11 [Page 14] is a time varying graph of fireworks noise associated with the Parachute Music Festival. The area marked 'A' on the graph denotes the fireworks display as measured at ground level approx 750m from the firing location.

Special Audible Characteristics and Low Frequency Sound

Most District Plans and Resource Consent Conditions require noise to be measured and assessed using the New Zealand Standards NZS 6801 and 6802, the most recent versions being NZS 6801:2008 Acoustics - Measurement of Environmental Sound and NZS

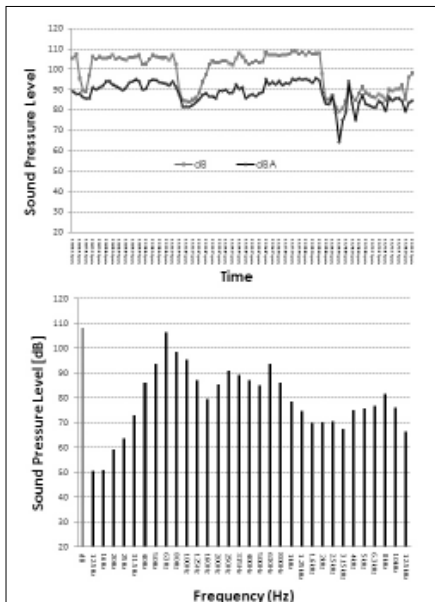


Figure 9: Sample of the measured time varying sound pressure level and third octave frequency analysis carried out approximately 30 m from the Main Stage at the Parachute Music Festival during a performance of a rock band. Ref: Malcolm Hunt Associates ©

6802:2008 Acoustics - Environmental Noise. Any special audible characteristics can attract up to a 6 dB penalty under these standards if judged to be present.

In regards to amplified music from concerts, special audible character such as bass beats is deemed to be more annoying or disturbing than the same level of sound without the special audible character present. In order to correctly identify the presence of a tone it may be necessary to carry out a narrow band frequency analysis however, a subjective assessment or measurements in third octaves will normally suffice.

NZS6801:2008 provides guidance on the objective assessment of tones. The method relies on the amount by which a 1/3 octave band sound level exceeds the average sound levels in the neighbouring bands, using the following thresholds:

- 15 dB for centre frequencies less than or equal to 125 Hz
- 8 dB for centre frequencies between 160 and 400 Hz
- 5 dB for centre frequencies above 500 Hz

The standard states that at frequencies below 500Hz the criteria could be too severe and although tones may be identified they might not be audible.

Sound from rock concerts generally contains high levels of sound energy in the low frequencies, and therefore special attention should be given to this component and not just the A-weighted levels as commonly required by District Plans. Low frequency sound in the 63 Hz octave band should typically be no more than 15 dB higher than overall A-weighted limits used in District Plans.

There are other compounding factors regarding low frequency sound from concerts [and other sources]. The

first is common building materials provide better sound attenuation at mid to high frequencies compared to low frequencies. Inside neighbouring dwellings this means the building envelope acts as a filter decreasing the proportion of mid to high frequencies, and hence it is often lower frequencies which we can hear inside i.e. the thudding bass sound.

Secondly, low frequency sound energy is not well attenuated by atmospheric absorption or barrier attenuation. Due to increasingly longer wavelengths, low frequency sounds are typically less directional than high frequency sounds. Any obstacle in the sound path will

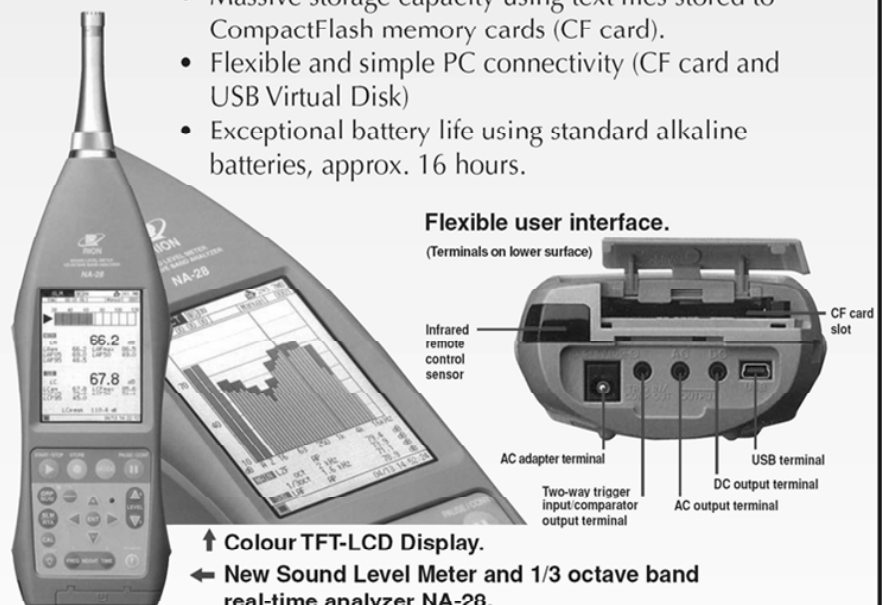
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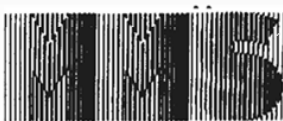
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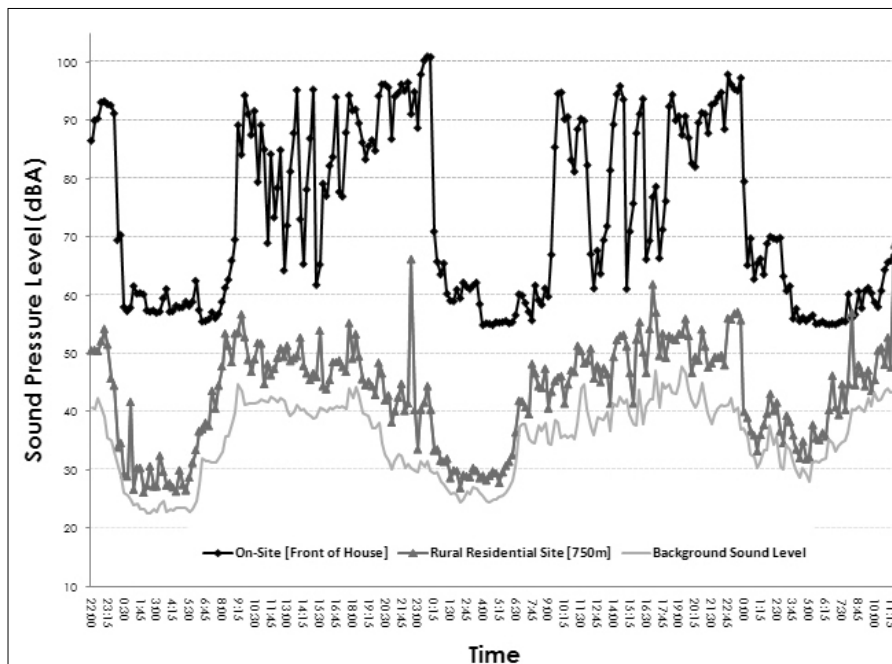


Figure 10: Sample of the measured time varying sound pressure level [dB] concurrent for onsite measurements and at a distant receiving rural residential location [approx 750 m] during a rock band performance. Ref: Malcolm Hunt Associates ©

partially reflect, absorb and transmit sound, but in general, an object must be of similar or larger dimensions to the wavelength in order to significantly interfere with sound. The wavelength of sound at 16 Hz is 22m while at 4000 Hz it is 0.085m. Sound with a wavelength of 0.085 m would be easily disrupted compared to sound with a wavelength of 22m which would be more difficult to disrupt.

Finally, if the wavelength of sound is large in comparison to the dimension of the source, it radiates uniformly in all directions. This means that low frequency sound cannot easily be directed away from neighbouring properties by orientation of the loudspeakers.

Figure 12 [Page 15] is a graph of third octave sound reductions for piece of 10mm float glass with surface mass of

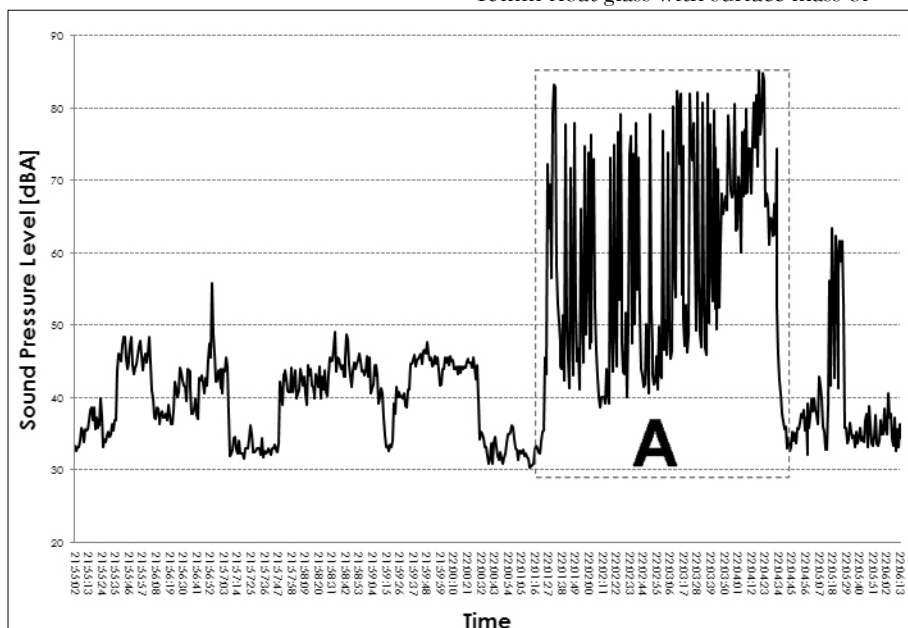


Figure 11 Sample of time varying graph of fireworks noise associates with open air concert. The area marked 'A' on the graph denotes the fireworks display. Ref: Malcolm Hunt Associates ©

approximately 25 kg/m² compared to 150 mm thick concrete block with a surface mass of approximately 350 kg/m². Regardless of the overall mass both materials perform better in the higher frequencies.

World Health Organization Guidelines

The World Health Organization recommends various guidelines for specific environments. In the case of bedrooms the critical effect is sleep disturbance, where guideline indoor limits are 30 dB LAeq [8 hr] for continuous noise and 45 dB L_{Amax} for single sound events. The World Health Organization does however acknowledge that lower levels may be annoying depending on the nature of the sound source.

In addition to sleep protection the World Health Organization also give guidelines for the protection of people's health and amenity outdoors. To stop people 'being seriously annoyed' the World Health Organization recommends an outdoor sound level from steady, continuous noise on balconies, terraces, and in outdoor living areas of no more than 55 dB LAeq [16hrs]. To protect the majority of people from being 'moderately annoyed' during the daytime, the outdoor sound level should not exceed LAeq 50 dB LAeq [16hrs] [1].

Table 2 [Page 15] is a summary of the World Health Organization guidelines for outdoor living and dwelling spaces, with a description of the related critical health effects.

Concerts can occur during both day and night. Sleep disturbance due to continuous, as well as intermittent sound, has been demonstrated by electrophysiological and behavioural research. The more intense the background sound is, the greater its potential effect on sleep may be.

The night time sleep disturbance threshold set out in Table 2 was re-examined by the World Health Organization last year in a document entitled 'Night Noise Guidelines for Europe'. Accordingly the design level was lowered from 45 dB LAeq [8hrs] to 40 dB LAeq [8hrs] outside of dwellings [also written as [L_{night}, outside]]. No

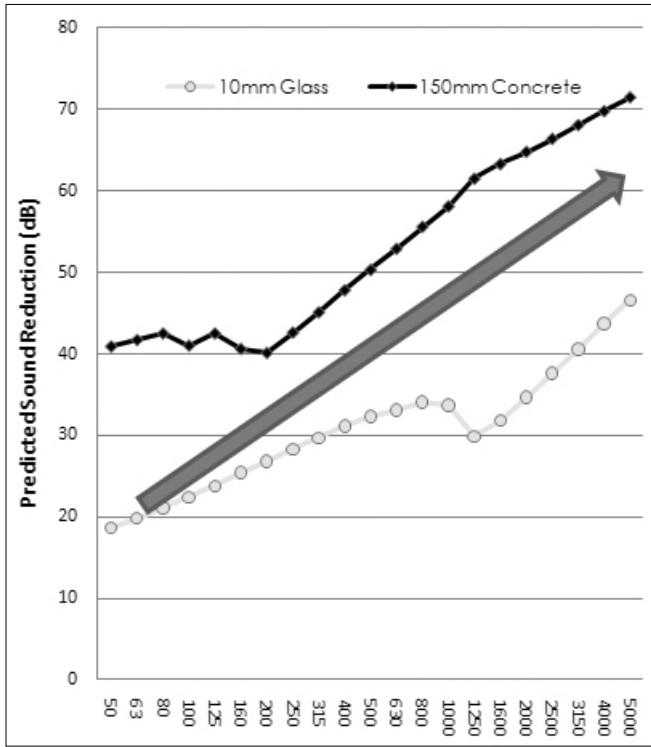


Figure 12 Graph of third octave sound reductions for two common materials. Note arrow indicated as frequency increases so does predicted sound reduction of materials Ref: Malcolm Hunt Associates ©

inside value was specified in the review. An interim level of 55 dB LAeq [8hrs] was set.

Annoyance

It is common for people in dwellings or outdoor living areas to be annoyed by sound from concerts.

The World Health Organization defines annoyance as ‘a feeling of displeasure evoked by noise’. This relates to both acoustic and non-acoustic factors, including social, psychological,

and economic issues. There are considerable differences in individual reactions in the same sound [1].

Guski [2] states a number of social moderators exist regarding annoyance including evaluation of the source and suspicion of those who control the source. Figure 13 [Page 16] modified from Guski emphasises the central nature of personal factors moderating annoyance.

Noise Management Methods

Effective management of the overall sound levels during a concert will rely on the total output and control of the sound system[s]. Effective management and control can mean that surrounding neighbours do not have to be annoyed or disturbed by noise from open air concerts.

Amplified sound generally presents the biggest challenge for noise mitigation. The amplified sound during an event is controlled by Mix Engineers at the sound desk, which is usually located in front of the stage.

Environment	Critical Health Effect(s)	LAeq [dB(A)]	Time base [hours]	LAmx [dB(A)]
Outdoor living area	Serious annoyance, daytime and evening Moderate annoyance, daytime and evening Sleep disturbance, windows open	55	16	-
		50	16	-
		45	8	60
Dwelling, indoors	Speech intelligibility, Moderate annoyance, daytime and evening Sleep disturbance, night-time	55	16	-
		30	8	45
Bedrooms, indoors	Seep disturbance	30	8	45
Ceremonies, festivals and entertainment events, indoor or outdoor Public addresses	Hearing impairment (patrons:<5 times/year)	100	4	110
	Hearing impairment	85	1	110

Table 2: World Health Organisation Guidelines. Reference: WHO 1999 Community Noise – Guideline Document

General management methods for the sound system include:

- Positioning of the loudspeakers close to the ground can limit noise emissions off-site,
- Design and orientation of the loudspeakers facing away from noise sensitive sites,
- Orientation and positioning of stages in areas to minimise on-stage noise at residential or noise sensitive sites,
- Control of sound levels and the spectral characteristics of the sound i.e. low frequencies.

The following provides more detailed noise management methods for open air concerts. The methods presented will not be suitable for all events and all sites, but provide an overview of common methods available.

Limiters, Compressors and Sound Level Indicators

Noise limiters/compressors are electronic devices which may be used to set the maximum volume. Generally calibration and setting of maximum noise levels using such a device occurs before the event. This allows the Audio Engineer to work with Acoustic Consultant to measure and assess overall sound levels in the environment and address potential issues from low frequency sound.

Calibration will not always ensure compliance as weather effects [wind, temperature inversions etc] may alter sound levels and characteristics during the actual event. Therefore noise monitoring is still carried out during the event. If measured levels show potential non compliance the acoustic consultant should relay this to the Mix Engineers who can make suitable changes.

A limiting device or indicator either has a microphone which measures music sound levels noise at the sound control desk, or monitors the electric signal from the sound system output. If the music exceeds a pre-set level the device will provide a switch that can either cut a power supply or trigger a warning light. For small bars and nightclubs it may be appropriate to cut the sound system power supply, but for major events only a warning light could be used.

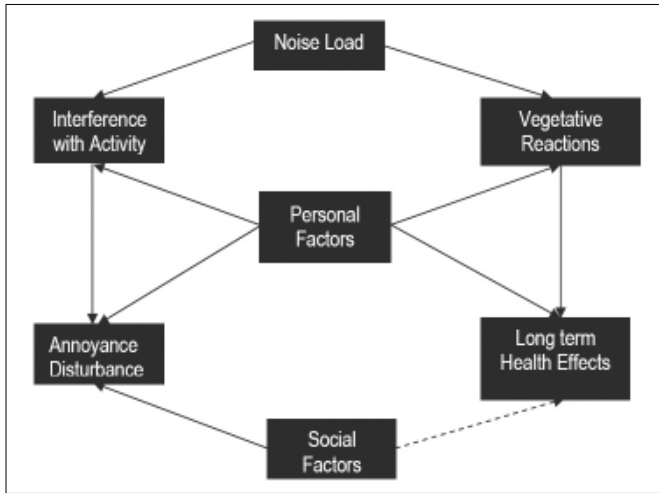


Figure 13: Factors moderating potential noise annoyance.

Reference: Guski. Personal and social variables as codeterminants of noise annoyance. Noise and

A compressor is also a useful tool in some situations as this works solely within the electrical signal in the sound system and maintains and controls the overall sound level at a constant volume rather than cutting off the power.

For complex concert sound systems there are issues using these devices as

the performers are aware of the sound they are producing. The sound desk is not always in control of 'total volume' of sound produced from the stage and hence careful design, management and control needs to be exercised to ensure compliance with applicable limits.

Noise Liaison Manager

there are multiple electrical signal paths. There is also significant resistance from many Audio Engineers to the introduction of devices which may degrade sound quality.

Frontline Speaker Control

One key area which may not be controlled by main Mix Engineer is the 'frontline' of speakers positioned on stage. As their name suggests 'frontline' speakers face the musicians so

The organisers and management of the event should ensure the operators of each sound system will be provided with advice on the set up and operation of the sound system to ensure noise emissions are not unreasonable. In this respect, a liaison person is required whose specific duty is to oversee personnel operating the sound system, and be in charge of noise control procedures to be followed in the event that noise complaints are received.

In summary the noise liaison manager's specific duties should be:

- Ensure noise control procedures are followed;
- To organise action following any noise complaints received;
- To receive and circulate monitoring results throughout the event;
- To direct and oversee personnel operating sound systems.

Acoustic Consultant


The acoustics consultant is employed to carry out an assessment of potential noise effects from the concert. The acoustic consultant's responsibilities may then include calibration of the sound





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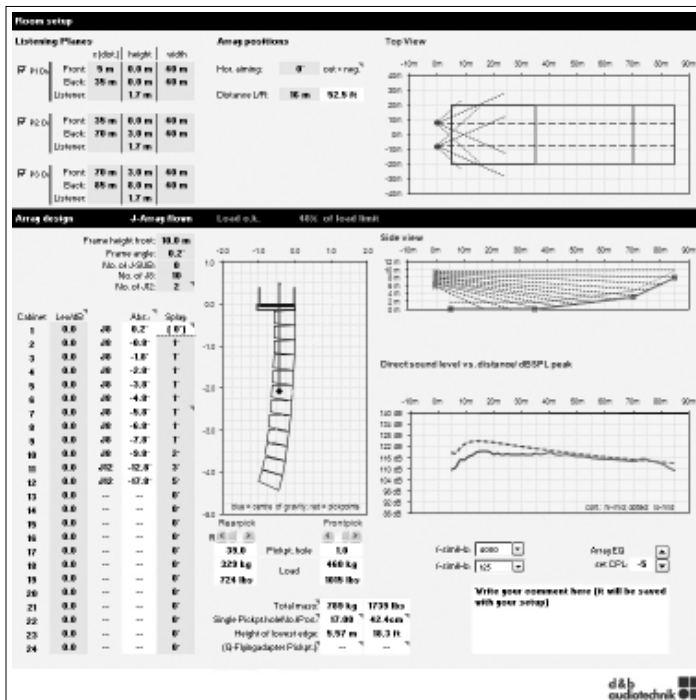


Figure 14: Input screen shot of the d&b audiotechnik ArrayCalc. Ref www.dbaudio.com

system in conjunction with the Audio and Mix Engineers, and monitoring during the concert. The consultant reports to the events noise liaison manager who would have the ability/authority to implement instant changes to sound levels during the event by providing instruction to Mix Engineers.

The Acoustic Consultant may also assist in the preparation of a specific Noise Management Plan for the event. The noise management plan should as a minimum set out the:

- Objectives of the plan;
- Applicable noise limits;
- Assessment locations for measurements;
- Consultation process;
- Noise management and control methods [physical and managerial] – this includes the speaker set up and design;
- Noise monitoring procedures;
- Non-compliance noise monitoring procedures;
- Reporting requirements.

Audio Engineer

An Audio Engineer should design the sound system for the activity and site requirements. A competent and

experienced Audio Engineer will work within restrictions such as noise limits set by territorial authorities.

Accordingly they will need to be briefed when employed so they are prepared to accept direction and responsibility regarding sound levels.

There are various tools used by Audio Engineers for noise management, which should be considered at an early stage in the sound

system design. Options for limiting environmental noise include use of distributed or directional sound systems. The Westpac Stadium has a distributed system with many smaller speakers around the circumference of the stadium as opposed to one larger speaker cluster. These distributed speakers are orientated downwards towards the crowd seated below.

An example of a design tool for directional systems is ArrayCalc produced by d&b audiotechnik. This is a simulation tool used for loudspeaker arrays, which helps optimise the quantity and aiming of loudspeakers. Such systems use complex time delays of sound to each loudspeaker in the array to direct sound to the audience, and can reduce sound towards neighbours.

Figure 14 [Page 17] is a screen shot of the d&b audiotechnik ArrayCalc [3]

Mix Engineer

Mix engineers manage the actual operation of the sound system/desk. This is a specialist job and possibly one of the most important in the control and balance of sound during concert events. The mix engineer is a person employed at the location where the main sound system is controlled. The Acoustic Consultant and Audio Engineer,

along with Mix Engineer, work closely during concert events to ensure legal requirements are being complied with at all times.

Consultation & Liaison with the Community

Consultation with the surrounding community is important to ensure there are 'no surprises'. Appropriate consultation should be undertaken to ensure that people living within the 'noise affected area' are aware of the event beforehand and its potential noise effects. There are two stages of consultation and liaison. The first being to receive feedback and submissions during the consent or other RMA process.

The second stage is liaison to provide the community with information prior to each event, such as when it will occur and who to contact with complaints. Neighbours should also be advised of any expected times and durations of sound checks.

It is common for most events to be advertised in various media, including many events having their own web pages. Community liaison may include leaflet drops in the local area prior to the event.

Additional consultation other than with the community may include meeting with Environmental Health Officers at the Council prior to the event to establish a protocol for handling noise complaints, should they arise during the event.

Performer Awareness and Contracts

As part of the management of the site it is key that performers are aware of requirements such as noise limits. In the case of large concerts where professionals set up and run the events and also control overall sound levels this is not usually a concern for performers. However for smaller events and local concerts bands may set up their own equipment and run sound desks, in which case performers and support personnel should be made aware of any noise limits and potential problems. In certain cases organisers should include written clauses in contracts in order to retain effective control over the permitted sound levels.

Production Company

In regards to large events it is not uncommon to hire a production company which takes care of a number of key issues such as lighting and audio design, set up and management. The Production Manager may also be responsible for employment of the acoustic and audio consultants. It is an advantage to use a single production company or manager to run an event with multiple stages and sound sources. It is also an advantage if the same acoustic, audio and mix engineers are assigned to a particular job or sound stage throughout the event, and are based in one place during the event.

In the case of large festivals it is common to have multiple performers and multiple stages. When more than one stage is used these should be spread out so that simultaneous performances held at different stages don't draw large crowds in one place. It is also important to ensure music sound from the sound system of one stage does not interfere with another stage as noise levels could be increased as a result. Using a single production company and/or manager should ensure design and layout to avoid conflict. Professional bands also travel with their own production and audio teams.

Fireworks, Pyrotechnics, Helicopters

It is common for open air concerts to have various additional sound sources, which may cause potential disturbance to neighbours. These could include fireworks, helicopter overflights, filming the event, carnival rides on site or pyrotechnics let off on stage. In terms of management methods to minimise noise effects, fireworks it is key to minimise disturbance to local residents [and animals] around the site. Displays should be as short as possible, with the minimum use of loud explosive fireworks. The manufacturer should be contacted to ascertain sound levels before these are used.

Helicopters associated with the media or production companies often overfly events. For helicopter associated with the event, controls such as flight tracks, minimum heights and hours of operation should apply. There are many other management methods which are possible, generally methods are site specific and therefore require professional input of production companies through to acoustic consultancy from the beginning of the project.

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- [3] <http://www.dbaudio.com>

The information contained in this document is intended as an educational aid only and therefore any user should establish the applicability of the information or advice in relation to any specific circumstances by seeking advice from a professional acoustic consultant or suitably qualified and experienced expert in the field of audio, acoustical or electrical engineering.

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